<Division of Multidisciplinary Chemistry> Polymer Materials Science

Division of Multidisciplinary Chemistry
– Polymer Materials Science –

http://www.scl.kyoto-u.ac.jp/~kanaya2/e_index.html

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Prof GABRYS, Barbara J University of Oxford, UK, 21 May

Scope of Research

The structure and molecular motion of polymer substances are studied using mainly scattering methods such as neutron, X-ray and light with intension of solving fundamentally important problems in polymer science. The main projects are the mechanism of structural development in crystalline polymers from glassy or molten state to spherulites, the dynamics in disordered polymer materials including low-energy excitation, glass transition and local segmental motions; formation processes and structure of polymer gels; the structure and molecular motion of polyelectrolyte solutions.

KEYWORDS
Polymer Physics
Polymer Properties
Scattering
Neutron Scattering

Selected Publications

Kanaya T, Inoue R, Kawashima K, Miyazaki T, Tsukushi I, Shibata K, Matsuba G, Nishida K, Hino M: Glassy Dynamics and Heterogeneity of Polymer Thin Films, *J. Phys. Soc. Jpn.*, **78,** [041004-1]-[041004-9] (2009).
Ogawa H, Kanaya T, Nishida K, Matsuba G, Majewski JP, Watkins E: Time-resolved Specular and Off-specular Neutron Reflectivity Measurements on Deuterated Polystyrene and Poly(vinyl methyl ether) Blend Thin Films during Dewetting Process, *J. Chem. Phys.*, **131,** [114907-1]- [114907-7] (2009).
Rahman N, Kawai T, Mastuba G, Nishida K, Kanaya T, Watanabe H, Okamoto H, Kato M, Usuki A, Matsuda M, Nakajima K, Honmma N: Effect of Polylactide Stereocomplex on the Crystallization Behavior of Poly(L –lactic acid), *Macromolecules*, **42,** 4739-4745 (2009).
Nishida K, Ogawa H, Matsuba G, Konishi T, Kanaya T: A High-resolution Small-angle Light Scattering Instrument for Soft Matter Studies, *J. Appl. Cryst.*, **41,** 732-728 (2008).

In-situ Observation of Crystallization of Isotactic Polypropylene from Mesomorphic Phase

We have studied crystallization behaviour of isotactic polypropylene (iPP) from mesomorphic phase in structural point of view. Time-resolved wide-angle X-ray diffraction (WAXD) measurements during a heating process have been performed using a synchrotron radiation (SR) X-ray beam line at SPring-8, Japan. The heating process was so programmed to reproduce a thermal trace of differential scanning calorimetry (DSC) with a constant heating rate (10 °C/min) in order to compare the structural change with thermal behaviour. SR-WAXD sensitively detected the crystallization behaviour (Figure 1) and we have obtained fractions of alpha-crystal, mesomorphic and amorphous phases as a function of temperature. During the crystallization, not the amorphous fraction but the mesomorphic one is mainly consumed (meso-alpha transition). We have also determined the energy level of the mesomorphic phase (meta-stable state) relative to that of alpha-crystal (stable state), considering the balance among the fractions of alpha-crystal, mesomorphic and amorphous phases.

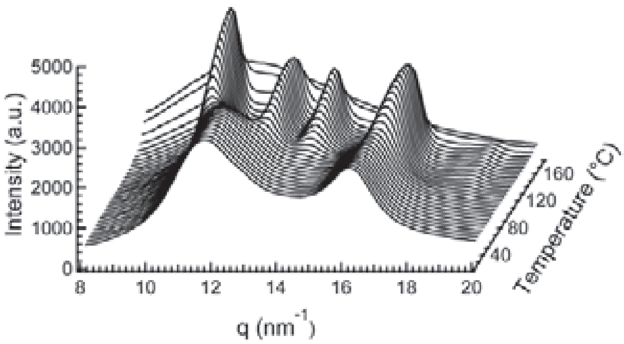

Figure 1. WAXD profiles during heating process from 30 to 170 °C displayed at every 5 °C from bottom to top. The profiles were shifted diagonally for clarification.

Dynamics of Amorphous Polymer Studied by Muon

The mechanism of glass transition and related glassy dynamics of glass-forming materials are still unresolved although so many experimental approaches have been conducted in the last two decades. To offer the new insight on the unresolved problems of dynamics of amorphous materials, we have studied the dynamics of amorphous polybutadiene (PB) by muon spin resonance (μSR). We have performed longitudinal field (LF) measurements with a 100 G magnetic field at temperatures from 10 K to 300 K. Figure 2 (a) shows an example of the decay of asymmetry for PB at 300 K and we could observe a decay of asymmetry originated from the dynamics of PB. The temperature dependence of relaxation rate is shown in Figure 2 (b) and the relaxation rate increased monotonically with temperature up to 180 K. Above 180 K (which is near to glass transition temperature of PB), we could observe a steep increase of relaxation rate, implying that the glass transition was detected by μSR. In addition to the detection of glass transition, we also observed a small increase of relaxation rate at round 120 K. This temperature corresponded to the onset temperature of local motion with the time scale of ps. From μSR studies, we succeeded to detect the dynamics of PB on a wide-time scale.

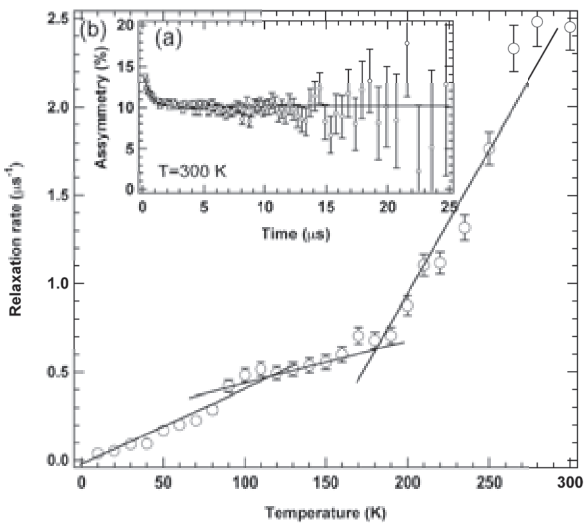

Figure 2. (a) Time dependence of the decay of asymmetry for PB at 300 K under a LF of 100 G. (b) Temperature dependence of the decay rate for PB. Lines are shown to clearly observe the onset of relaxation.